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VARIATION IN BODY DIMENSIONS AND PELAGE COLOR OF CERTAIN LABORATORY-BRED STOCKS OF THE PEROMYSCUS TRUEI GROUP

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INTRODUCTION

THE variation in dimensions of the body and skeleton and in the pelage color of certain laboratory-bred stocks belonging to 3 species of the Peromyscus truei group of small rodents is described in this report. The parents of these stocks were originally captured in the states of Arizona, Colorado, New Mexico, and Texas.

The Peromyscus truei group consists, according to Hoffmeister (1951), of 4 species: truei, nasutus, bullatus, and difficilis. To these must be added the species comanche of Blair (1943).

Hoffmeister considers comanche to be a subspecies of nasutus, a conclusion which I cannot accept because of partial infertility between these forms. The species group ranges from Oregon to Colorado and southward to Texas and over the highlands of Mexico, including Baja California. They are mice of fairly large size. All of them have conspicuous ears, which in truei are exceptionally large. In the United States these mice generally occupy xeric habitats of open woodland and brush on the mountain slopes, but certain populations live in rock and shrub-covered habitats on the xeric parts of the high plains. Peromyscus truei sometimes ascends into the open coniferous-forest habitats of the lower part of the montane belt. In many areas the 2 species truei and nasutus occur together, sometimes in the same habitats, but without interbreeding (Dice, 1942).

Acknowledgments

The expense of rearing the Peromyscus which are here described was in part borne by the Museum of Zoology, in part by the Laboratory of Vertebrate Biology, and in part by research grants from the Faculty Research Fund, University of Michigan. The several expeditions on which most of the breeding stocks were secured were supported in part by the Museum of Zoology, Laboratory of Vertebrate Biology, Carnegie Institute of Washington, and Cranbrook Institute of Science, by special gifts from Bryant Walker and from W. P. Harris, Jr., and by contributions from the members of the expeditions. The Tule Canyon stock was presented by Milton F. Landwer. The B, C, and E stocks from Highrolls were presented by Philip M. Blossom.

For the tabulation of the measurements and for the statistical computations I am indebted to John A. King and to William Prychodko. The map and figures were drawn by Grace Yesley.

METHODS OF STUDY

All the mice herein described were born in the laboratory and after being reared under standard conditions to an approximate age either of 1 year or of 2 years were killed and prepared as specimens. The body measurements were made by myself immediately after each animal had been killed by ether and while it was still completely relaxed (Dice, 1932: 5-7). The measurements of the cleaned skull and femur and the color readings were made by various assistants.

For the measure of pelage color 2 methods have been employed. Reflection-meter readings of the flat skins were made with a Photovolt reflection meter according to the method previously described by me (Dice, 1947: 5). For several of the stocks tint-photometer readings were made in the same manner and by the same Hess-Ives instrument as those previously made by myself of other specimens of Peromyscus (Dice, 1932: 19). The readings by both instruments are given in terms of the percentage of light of the specified color which is reflected from the specimen in comparison with the amount reflected from a magnesium carbonate block, the reflectance of which is taken to be 100 per cent. The color screens used in the 2 instruments differ in the wave lengths of light they transmit and consequently their readings are not fully comparable.

For the calculation of variances and standard deviations, the sum of the squared deviations from the mean has been divided by n - 1. The significance of differences between means has been mostly estimated by the method of Dice and Leraas (1936), in which the t value of significance is taken to be about 2.7. For more critical comparisons the t value of the difference between each pair of means has been calculated separately.

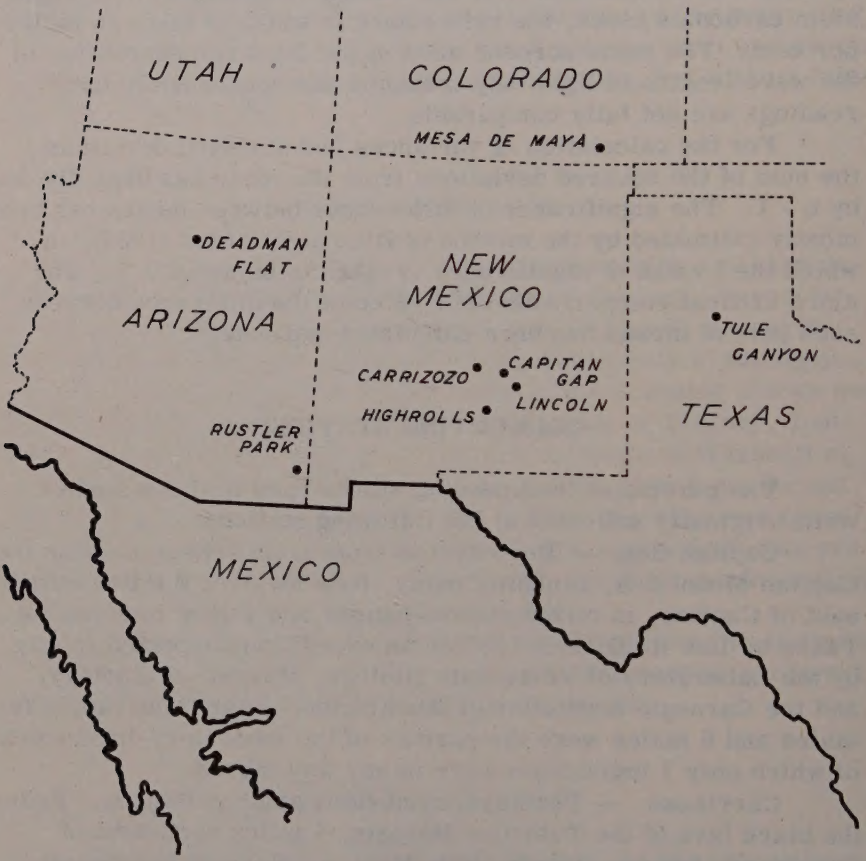
COLLECTING STATIONS

The parents of the breeding stocks used in these studies were originally collected at the following stations:

Capitan Gap. — Peromyscus truei truei. Near Capitan Gap, Capitan Mountains, Lincoln County, New Mexico, 6 miles northeast of Capitan, in mixed pinyon-juniper and yellow pine habitat. Taken by Lee R. Dice in 1937 on an expedition supported jointly by the Laboratory of Vertebrate Biology, Museum of Zoology, and the Carnegie Institution of Washington. Four field-caught females and 6 males were the parents of the laboratory-bred stock, of which only 7 individuals were in any way inbred.

Carrizozo. — Peromyscus nasutus griseus Benson. From the black lava of the Tularosa Malpais, 4 miles northwest of Carrizozo, Lincoln County, New Mexico. Various individuals were trapped by G. W. Bradt in 1928 and 1929 (Bradt, 1932), by S. B. Benson in 1931, and by Lee R. Dice in 1937, on expeditions supported in part by the Carnegie Institution of Washington, in part by the Museum of Zoology, and in part by the Laboratory of Vertebrate Biology. The considerably inbred laboratory stock was derived from 2 field-caught females and 2 males.

Deadman Flat. — Peromyscus truei truei. From rabbitbrush habitat in Deadman Flat, 15 to 20 miles north of Flagstaff, Coconino County, Arizona. Taken in 1932 by members of an expedition, led by G. W. Bradt and including R. K. Knox, A. J. Nicholson, A. M. Stebler, and H. J. Walt, which was supported in part by the Carnegie Institution of Washington. The laboratory-bred stock was derived from 4 field-caught females and 3 males. Of the 1 year age class only 1 individual was inbred, but of the 2-year class about half were more or less inbred.



MAP 1. Localities at which the stocks were collected.

Highrolls A. — Peromyscus truei truei. From pinyon-juniper woodland 1/2 mile west of Highrolls, Otero County, New Mexico (Dice, 1930). Taken in the summer of 1927 by G. W. Bradt, Robert Bradley, S. C. Whitlock, and Lee R. Dice, on an expedition from the Museum of Zoology supported in part by Bryant Walker and by W. P. Harris, Jr. The laboratory stock consists of a single sibship derived from a pair of field-caught animals.

Highrolls B, C, and E. — Peromyscus nasutus nasutus. From vicinity of Highrolls, Otero County, New Mexico. Taken in summer of 1936 by Philip M. Blossom. Station B is located 1-1/2 miles west of Highrolls at 6000 feet, in mountain mahogany and sumac habitat, just below the pinyon-juniper belt. Station C is 1 mile west of Highrolls at 6300 feet, near the lower limit of the pinyon-juniper belt. Station E is 3 miles east of Highrolls at an elevation of 7500 feet near the upper limit of the pinyon-juniper belt. These stocks were used only for testing intraspecific fertility and are not included in the tables of measurements.

Lincoln. — Peromyscus nasutus nasutus. From mountain slopes covered with pinyon-juniper woodland 4 miles northwest of Lincoln, in Lincoln County, New Mexico, near a locality called "Double-crossing." Taken in 1937 by Lee R. Dice on an expedition supported jointly by the Laboratory of Vertebrate Biology, Museum of Zoology, and the Carnegie Institution of Washington. The laboratory stock was derived without inbreeding from 6 field-caught females and 3 males.

Mesa de Maya. — Peromyscus truei truei. From pinyon and juniper habitat at the north base of the Mesa de Maya, in Las Animas County, Colorado, about 45 miles east of Trinidad. Taken by Lee R. Dice in 1925 on an expedition from the Museum of Zoology which was supported in part by the Carnegie Institution of Washington. A single pregnant female taken in the field in 1925 gave birth in the laboratory to 2 sons, one of which died and the other was mated to his mother to produce this highly inbred stock.

Rustler Park. — Peromyscus nasutus nasutus. From yellow-pine habitat in Rustler Park, upper part of the Chiricahua Mountains, Cochise County, Arizona. Taken in summer of 1932 by Victor Cahalane on an expedition from Cranbrook Institute of Science which was in part sponsored by the Desert Laboratory of the Carnegie Institution of Washington. The laboratory stock was derived from 3 field-caught females and 3 males. About one-third of the individuals both in the 1-year and 2-year age classes were somewhat inbred.

Tule Canyon. — Peromyscus comanche Blair (1943). From the rocky slopes of Tule Canyon, 22 miles east of Tulia, in Briscoe County, Texas. Trapped in 1932 by Milton F. Landwer. The laboratory stock was produced from 3 field-caught females and 3 males. Three of the individuals in the 1-year age class and 6 in the 2-year class were somewhat inbred.

VARIATION DUE TO AGE

For the measure of age variation in the body and skeletal dimensions of the mice there are available, for 5 stocks, series of specimens both of the 1-year (36-78 weeks) and of the 2-year (79 and up weeks) age classes (Table I).

TABLE I

Differences in Dimensions and in Pelage Color between 2-year and 1-year Age Classes in the Peromyscus truei Group

Mean of the 2-year class minus mean of the 1-year class and standard error of the differences. Males and females are combined in each age class. Measurements of body dimensions in millimeters, of pelage color in reflection-meter readings.

Character	truei		nasutus	griseus	comanche
	Deadman Flat	Mesa de Maya	Rustler Park	Carrizozo	Tule Canyon
Dimensions					
Body length . . .	1.52 ± .94	4.68 ± .78	4.27 ± .80	3.97 ± .70	2.58 ± .74
Tail length . . .	.06 ± 1.11	4.36 ± .83	1.76 ± 1.23	2.55 ± 1.60	1.94 ± 1.22
Hind foot length .	-.326 ± .167	.230 ± .111	.296 ± .156	.345 ± .122	.080 ± .182
Ear length . . .	.409 ± .248	1.233 ± .178	.328 ± .214	.783 ± .176	.249 ± .249
Femur length . .	-.009 ± .146	.868 ± .107	.709 ± .126	.385 ± .173	.429 ± .143
Mandible length .	.254 ± .106	.716 ± .100	.550 ± .124	.496 ± .109	.450 ± .117
Condyle-premaxilla length . .	.218 ± .147	.784 ± .100	.754 ± .141	1.031 ± .170	.432 ± .153
Condyle-zygoma length	.203 ± .101	.433 ± .069	.389 ± .094	.379 ± .132	.297 ± .108
Bullar Width . .	.013 ± .069	.166 ± .042	.177 ± .062	.292 ± .052	.154 ± .072
Reflection-meter readings					
Dorsal stripe					
Red	1.26 ± .51	.98 ± .51	.18 ± .31	-1.06 ± .45	.34 ± .44
Green	-.02 ± .27	.65 ± .34	.15 ± .21	.49 ± .25	.50 ± .24
Blue	-.19 ± .18	.15 ± .24	-.17 ± .14	-.18 ± .15	.46 ± .19
Side stripe					
Red	1.67 ± .72	.86 ± 1.00	.62 ± .54	.19 ± .71	1.81 ± .99
Green	.17 ± .45	.93 ± .48	.17 ± .37	.44 ± .47	1.32 ± .52
Blue	-.31 ± .29	.18 ± .31	.12 ± .22	.13 ± .31	.35 ± .33

In hind-foot length the Mesa de Maya 2-year-old mice exceed the 1-year mice by an average of .230 ± .111 mm, an amount which is significant at the 5 per cent level. The Deadman Flat 2-year class averages smaller in this measurement than the 1-year class by .326 ± .167mm, an amount which is close to the 5 per cent level of significance. In the other 3 stocks here compared, the 2 age classes do not differ significantly from one another in foot length. I conclude that in the truei group there is no good evidence for growth in foot length between the first and second years of life.

In all the other measurements of the body and skeleton the 2-year-old mice exceed the 1-year class, the only exception being for femur length in the Deadman Flat stock, in which the 1-year class averages .009 ± .146 mm the larger, a nonsignificant difference. For the several measurements the excess of the 2-year over the 1-year animals ranges in the various stocks from not significant to highly significant. For no measurement is the difference between the age classes significant at the 1 per cent level for all the stocks. For mandibular length and condylo-zygomatic distance the 2-year mice significantly exceed the 1-year mice at the 5 per cent level in all the stocks. For the other measurements the age classes fail to differ significantly in all the stocks, though they always do so in at least 1 stock. The general impression is that except for length of hind foot, the 2-year old mice average slightly larger in nearly all of their measurements than the 1-year mice.

The differences in pelage color readings between the 2-year and 1-year old mice are not very great and are inconsistent among the 5 stocks here compared. For no color reading are the differences between the age classes significant in all 5 stocks. Most of the differences are statistically insignificant. So far as these measurements can be relied upon, there is no evident difference in pelage color between the 1-year and 2-year age classes in the truei group.

VARIATION RELATED TO SEX

For the analysis of the effects of sex on variation in these mice, the measurements of body dimensions and of pelage color of the males and females of the 1-year age class of 2 stocks are compared in Table II. It is evident from this table that in most of their dimensions the males and females do not differ significantly. In ear length the males average larger than the females and in the Deadman Flat stock the difference is significant at the 5 per cent level, but in the Capitan Gap stock the difference between the sexes in this measurement is not significant. The females of the Capitan Gap stock average longer in mandibular length than the males, the difference being significant at the 5 per cent level. The males of the Deadman Flat stock, however, exceed the females in this measurement, though the difference is not significant. I conclude that there is no consistent difference between the sexes in these stocks of mice in any dimension of the body or skeleton.

TABLE II

Differences in Dimensions and in Pelage Color between Males and Females of Peromyscus truei

Means of the measurements of the males minus means of the females and the standard errors of the differences. Measurements of body dimensions in millimeters, of pelage color in reflection-meter readings; 1-year age class.

Character	Capitan Gap	Deadman Flat
Dimensions		
Body length	-.90 ± .80	1.36 ± 1.16
Tail length	-2.36 ± 1.44	-.60 ± 1.29
Foot length	.108 ± .116	.210 ± .214
Ear length	.096 ± .183	.620 ± .281
Femur length	-.253 ± .172	.034 ± .161
Mandible length	-.186 ± .079	.147 ± .124
Condyle-premaxilla length .	-.103 ± .127	.056 ± .131
Condyle-zygoma length . . .	-.128 ± .090	.074 ± .093
Bullar width	-.025 ± .062	-.015 ± .049
Reflection-meter readings		
Dorsal stripe		
Red	.40 ± .36	-.76 ± .63
Green	.03 ± .17	-.36 ± .33
Blue	.09 ± .15	-.04 ± .24
Side stripe		
Red	-.31 ± .71	-2.60 ± 1.17
Green	1.42 ± .42	.44 ± .54
Blue	.80 ± .27	.28 ± .33

The reflection-meter readings of pelage color also fail to exhibit any consistent difference between the sexes. In the Capitan Gap stock the males of the 1-year class significantly exceed the females in readings for green and for blue of the light reflected from the side of the body, but in the Deadman Flat stock the females exceed the males in the readings of red from the side stripe. In all the other color readings the sexes do not differ significantly.

In view of the lack of any consistent difference in the truei group between the males and females in any body or skeletal dimension or in pelage color, I have combined the measurements for the 2 sexes in the analysis of other aspects of variation among these mice.

The failure to discover consistent differences in dimensions or in pelage color between the males and females of the truei group is at variance with the conditions in some other species of Peromyscus. In Peromyscus maniculatus (Dice, 1932, 1933a) and in P. leucopus (Dice, 1937) the males average larger than the females in hind-foot length. In leucopus the males also may exceed the females in average body length. In the species polionotus, on the contrary, the females exceed the males in certain measurements (Sumner, 1926), though not in foot length (Hayne, 1950). In Peromyscus eremicus, also, the females average larger than the males and, in addition, they average slightly paler than the males in pelage color (Dice, 1939).

Sexual dimorphism in dimensions and in pelage color seems consequently to be a highly individual matter among the mice of the genus Peromyscus. In certain species the males average the larger in certain dimensions, while in other species the females average larger than the males in these same dimensions. Hayne (1950) has shown that, even within a single subspecies, a stock from one locality may exhibit sexual dimorphism in certain dimensions, while a neighboring stock may fail to show any significant difference between the sexes in these particular characters.

VARIATION IN DIMENSIONS AND WEIGHT

None of the stocks averages consistently larger or smaller than all the others in any dimension of the body or skeleton, though certain stocks do rank significantly larger or smaller than most of the others in one or more measurements.

In body length the Capitan Gap stock, which has a mean of 107.66 mm for the 1-year class, averages significantly longer than all the other stocks (Table III). The Lincoln, Rustler Park, Tule Canyon, and Deadman Flat stocks all average significantly longer than the Carrizozo stock, which in its turn significantly exceeds the Highrolls and Mesa de Maya stocks. The Mesa de Maya mean is 97.12 mm.

Tail length exhibits the greatest amount of variation among the stocks of any of the measurements here taken, ranging from a mean of 115.53 mm for the 1-year old mice of the Rustler Park stock to only 87.79 mm for the Mesa de Maya stock (Fig. I). The Rustler Park stock significantly exceeds in this measurement the Lincoln stock, which in its turn significantly exceeds all the others. The Mesa de Maya stock averages significantly shorter in tail length than all the other stocks. The Tule Canyon stock significantly

TABLE III

Measurements of the Peromyscus truei Group

Means, standard errors, and standard deviations in millimeters.

Stock	Age Class	Sex	No.	Field-caught Parents	Mean Age (in Weeks)	Body Length	Tail Length	Hind-foot Length	Ear Length
truei									
Capitan Gap	1 yr.	♂♂	41	10	56	107.24 ± .52 (3.34)	93.13 ± 1.01 (6.20)	23.028 ± .058 (.370)	25.242 ± .123 (.758)
	1 yr.	♀♀	36	7	53	108.14 ± .60 (3.62)	95.49 ± 1.03 (6.10)	22.920 ± .100 (.590)	25.146 ± .135 (.748)
	1 yr.	♂♀	77	10	55	107.66 ± .40 (3.48)	94.26 ± .73 (6.23)	22.977 ± .069 (.598)	25.196 ± .091 (.773)
Deadman Flat	1 yr.	♂♂	27	7	62	104.52 ± .86 (4.48)	91.27 ± .90 (4.21)	23.719 ± .153 (.796)	26.533 ± .195 (1.015)
	1 yr.	♀♀	32	6	54	103.16 ± .78 (4.40)	91.87 ± .93 (5.09)	23.509 ± .149 (.843)	25.913 ± .202 (1.145)
	1 yr.	♂♀	59	7	58	103.78 ± .58 (4.45)	91.62 ± .65 (4.70)	23.605 ± .107 (.821)	26.197 ± .146 (1.123)
	2 yr.	♂♀	33	5	103	105.30 ± .74 (4.27)	91.68 ± .90 (4.49)	23.279 ± .128 (.737)	26.606 ± .200 (1.148)
Highrolls A	1 yr.	♂♀	20	2	61	97.40 ± 1.02 (4.56)	95.22 ± 2.04 (6.12)	22.885 ± .107 (.479)	25.080 ± .171 (.764)
Mesa de Maya	1 yr.	♂♀	52	2	47	97.12 ± .44 (3.16)	87.79 ± .51 (3.52)	22.808 ± .081 (.587)	23.272 ± .119 (.841)
	2 yr.	♂♀	40	2	124	101.80 ± .64 (4.08)	92.15 ± .65 (3.74)	23.038 ± .076 (.481)	24.505 ± .132 (.811)
nasutus									
Lincoln . . .	1 yr.	♂♀	64	9	53	104.89 ± .37 (2.94)	103.73 ± .61 (4.84)	23.275 ± .064 (.510)	22.435 ± .096 (.765)
Rustler Park	1 yr.	♂♀	44	6	51	104.70 ± .58 (3.83)	115.53 ± .68 (4.79)	23.269 ± .109 (.764)	21.981 ± .109 (.712)
	2 yr.	♂♀	36	6	118	108.97 ± .55 (3.22)	117.29 ± 1.02 (5.67)	23.565 ± .111 (.649)	22.309 ± .184 (1.041)
griseus									
Carrizozo . .	1 yr.	♂♀	78	4	55	100.78 ± .33 (2.94)	92.40 ± .58 (4.80)	22.186 ± .037 (.330)	22.541 ± .087 (.750)
	2 yr.	♂♀	32	3	140	104.75 ± .62 (3.52)	94.95 ± 1.49 (6.97)	22.531 ± .116 (.659)	23.324 ± .153 (.767)
comanche									
Tule Canyon	1 yr.	♂♀	54	6	53	104.11 ± .44 (3.27)	100.21 ± .59 (3.86)	22.520 ± .097 (.712)	22.196 ± .122 (.871)
	2 yr.	♂♀	32	6	105	106.69 ± .59 (3.35)	102.15 ± 1.07 (4.80)	22.600 ± .154 (.871)	22.445 ± .217 (1.168)

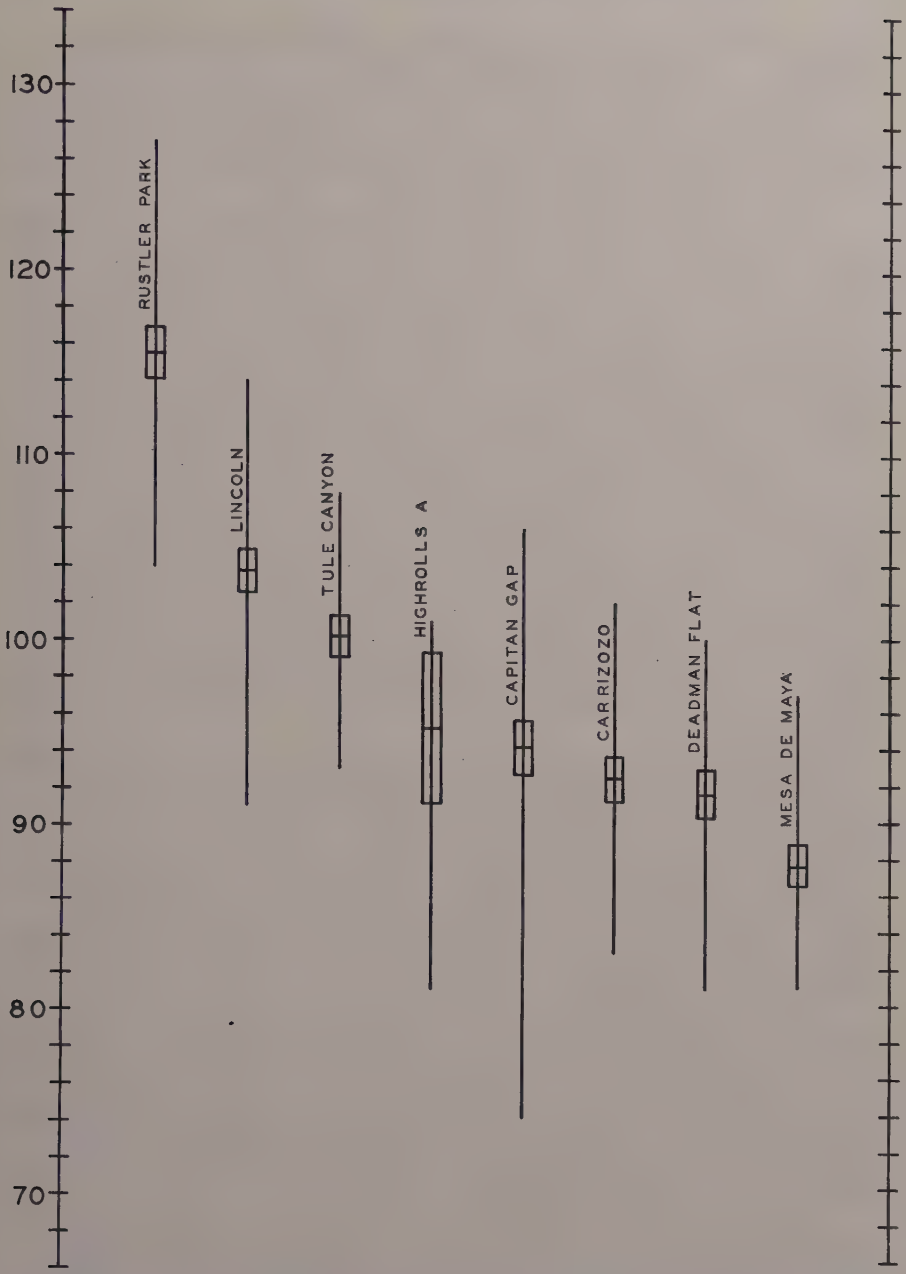


FIG. 1. Variation in tail length of laboratory-bred stocks of the Peromyscus truei group, shown by the graphical method of Dice and Leraas (1936). For each stock the length of the line represents the range in measurements, the rectangle indicates twice the standard error on each side of the mean, which is represented by the crossbar. In general, where rectangles do not overlap, the means differ significantly. One-year age class, both sexes.

exceeds in tail length the Capitan Gap, Carrizozo, and Deadman Flat stocks, but not the Highrolls A stock.

In length of hind foot there are relatively slight differences between the stocks. In the 1-year class the stock with the largest average hind foot (Deadman Flat) exceeds the stock with the smallest foot (Carrizozo) by only 1.419 mm.

In length of ear from notch there are conspicuous differences between the stocks. The Deadman Flat stock, with a mean of 26.197 mm for the 1-year class, significantly exceeds all the other stocks (Fig. 2). The Capitan Gap and Highrolls A stocks significantly exceed the Mesa de Maya stock, which in its turn significantly exceeds the Carrizozo, Lincoln, Tule Canyon, and Rustler Park stocks. The mean ear length of the Rustler Park stock, which averages the shortest in this measurement, is 21.981 mm.

In length of left femur the Capitan Gap stock, with a mean of 19.156 mm for the 1-year age class, significantly exceeded all the others (Table IV). The Deadman Flat, Rustler Park, and Lincoln stocks do not differ significantly from one another in this measurement, but they all significantly exceed the Highrolls A, Tule Canyon, and Mesa de Maya stocks. These 3 last stocks also do not differ significantly from one another, but they all significantly exceed the Carrizozo stock, which has a mean femur length of 17.412 mm.

Mandibular length differs only slightly among these 8 stocks, but some of the differences are of statistical significance. The Rustler Park stock, with a mean for the 1-year class of 17.942 mm, significantly exceeds all the other stocks. The Lincoln stock in its turn significantly exceeds in this measurement all but the Rustler Park stock. The Mesa de Maya stock, with a mean mandibular length of 16.458 mm, is significantly shorter in this character than any of the other stocks.

In condylo-premaxillary skull length the differences between the stocks are relatively slight. For the 1-year age class the mean for the Highrolls A stock, which is highest, is 27.811 mm, while for the Mesa de Maya stock, which is lowest, the skull length mean is 26.298 mm. The Mesa de Maya stock averages significantly shorter than all the other 7 stocks. None of the others fall into distinct size groups for this measurement.

The measurement of condylo-zygomatic distance also exhibits relatively slight variability among these eight stocks. The Highrolls A stock, with a mean for the 1-year age class of 19.989 mm, is highest and the Carrizozo stock, with a mean of 18.941 mm, is lowest.

In bullar width of skull the Highrolls A, Capitan Gap, and Rustler Park stocks do not differ significantly from one another, but all significantly exceed the other 5 stocks. The mean of the Highrolls A stock, which is highest of all, is 12.533 mm for the 1-year class, while the mean of the Carrizozo stock, which is lowest, is 12.068 mm.

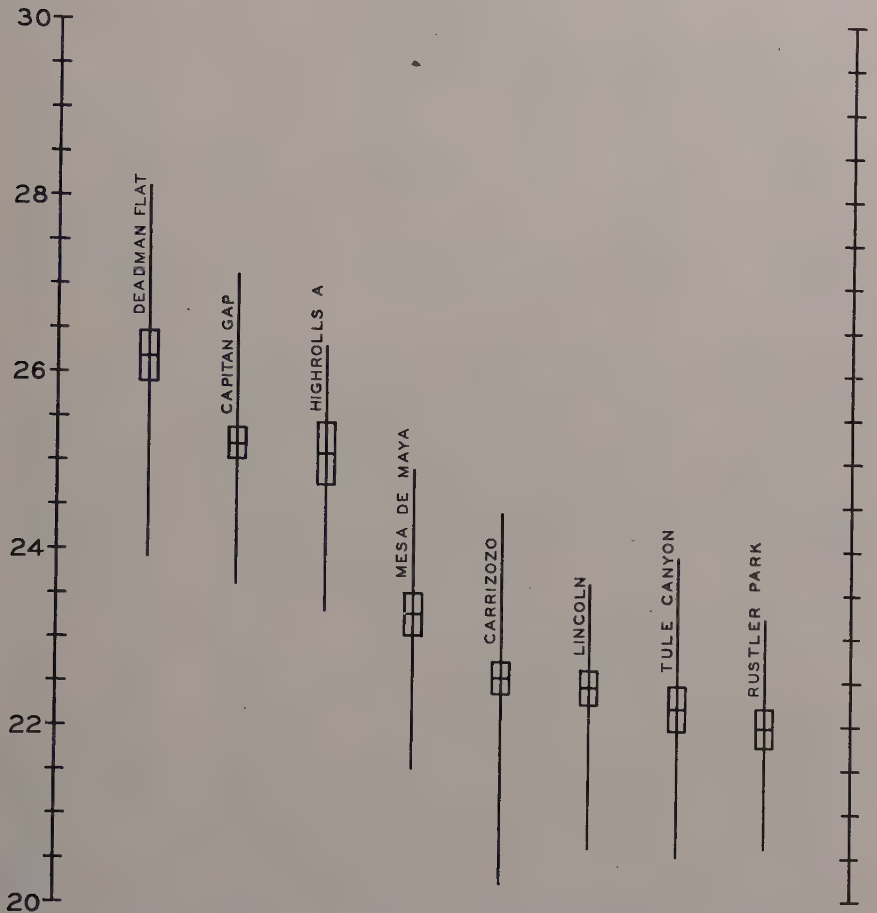


FIG. 2. Variation in ear length of laboratory-bred stocks of the Peromyscus truei group, shown by the same graphical method used in Figure 1. One-year age class, both sexes.

A small number of these animals were weighed at the time they were killed (Table V). The number of individuals weighed in each series is too small to serve as the basis for a reliable mean, in view of the considerable variation which occurs. The figures are presented here merely to show the average weight of laboratory-

TABLE IV

Measurements of the Peromyscus truei Group

Means, standard errors, and standard deviations are in millimeters.

Stock	Age Class	Sex	Femur Length	Mandible Length	Condyle-premaxilla Length	Condyle-zygoma Length	Bullar Width
truei							
Capitan Gap . .	1 yr.	♂♂	19.026 ± .106 (.592)	17.123 ± .047 (.259)	26.997 ± .087 (.475)	19.216 ± .058 (.322)	12.419 ± .042 (.232)
	1 yr.	♀♀	19.279 ± .130 (.745)	17.309 ± .067 (.388)	27.100 ± .092 (.534)	19.344 ± .069 (.404)	12.444 ± .046 (.269)
	1 yr.	♂+♀	19.156 ± .085 (.677)	17.220 ± .043 (.343)	27.052 ± .063 (.506)	19.283 ± .046 (.370)	12.432 ± .031 (.251)
Deadman Flat .	1 yr.	♂♂	18.444 ± .095 (.476)	17.292 ± .082 (.419)	26.992 ± .081 (.406)	19.140 ± .053 (.245)	12.195 ± .032 (.147)
	1 yr.	♀♀	18.410 ± .130 (.714)	17.145 ± .093 (.516)	26.936 ± .102 (.537)	19.066 ± .077 (.417)	12.210 ± .037 (.199)
	1 yr.	♂+♀	18.426 ± .083 (.612)	17.212 ± .063 (.476)	26.962 ± .065 (.476)	19.100 ± .048 (.353)	12.204 ± .025 (.177)
	2 yr.	♂+♀	18.417 ± .120 (.656)	17.466 ± .085 (.456)	27.180 ± .132 (.721)	19.303 ± .089 (.486)	12.217 ± .064 (.350)
Highrolls A . .	1 yr.	♂+♀	17.956 ± .075 (.319)	17.261 ± .082 (.348)	27.811 ± .125 (.529)	19.989 ± .080 (.339)	12.533 ± .047 (.200)
Mesa de Maya .	1 yr.	♂+♀	17.698 ± .077 (.554)	16.458 ± .064 (.477)	26.298 ± .066 (.482)	19.019 ± .044 (.325)	12.085 ± .021 (.155)
	2 yr.	♂+♀	18.566 ± .075 (.461)	17.174 ± .077 (.480)	27.082 ± .075 (.462)	19.462 ± .054 (.344)	12.251 ± .036 (.221)
nasutus							
Lincoln	1 yr.	♂+♀	18.234 ± .066 (.479)	17.562 ± .052 (.375)	27.266 ± .066 (.481)	19.374 ± .052 (.375)	12.206 ± .040 (.287)
Rustler Park .	1 yr.	♂+♀	18.291 ± .070 (.456)	17.942 ± .062 (.406)	27.438 ± .084 (.547)	19.248 ± .054 (.353)	12.386 ± .033 (.218)
	2 yr.	♂+♀	19.000 ± .105 (.547)	18.492 ± .107 (.547)	28.192 ± .113 (.575)	19.637 ± .077 (.400)	12.563 ± .052 (.268)
griseus							
Carrizozo. . .	1 yr.	♂+♀	17.412 ± .067 (.575)	17.075 ± .049 (.423)	26.689 ± .046 (.396)	18.941 ± .046 (.395)	12.068 ± .030 (.265)
	2 yr.	♂+♀	17.797 ± .160 (.876)	17.571 ± .097 (.542)	27.720 ± .164 (.899)	19.320 ± .124 (.677)	12.360 ± .043 (.236)
comanche							
Tule Canyon. .	1 yr.	♂+♀	17.900 ± .061 (.426)	16.898 ± .060 (.426)	26.620 ± .076 (.489)	18.962 ± .053 (.344)	12.124 ± .040 (.235)
	2 yr.	♂+♀	18.329 ± .129 (.684)	17.348 ± .100 (.538)	27.052 ± .133 (.714)	19.259 ± .094 (.508)	12.278 ± .060 (.314)

reared mice of the truei group. It will be noted that the mean weights center fairly closely around 30 grams.

TABLE V

Individual Weights in the Peromyscus truei Group

Means, standard errors, and standard deviations are in grams.

Stock	Age Class	Males		Females	
		Number	Mean ± S.E. (S.Dev.)	Number	Mean ± S.E. (S.D.)
truei					
Mesa de Maya	1 yr.	28	28.11 ± .61 (3.24)	28	26.46 ± .70 (3.73)
	2 yr.	16	32.21 ± 1.73 (6.93)	15	30.05 ± 1.71 (6.64)
Deadman Flat	1 yr.	16	35.81 ± 1.18 (4.71)	13	30.08 ± 1.64 (5.92)
nasutus					
Tule Canyon	1 yr.	16	31.81 ± 1.07 (4.30)	17	31.88 ± 1.44 (5.95)

In summary, the 8 stocks of the truei group which are here compared exhibit relatively slight differences in mean hind-foot length, and in the measurements of the skull. The most conspicuous variation among the stocks is in the length of the tail, which varies from a mean of 115.53 mm for the 1-year age class of the Rustler Park stock to a mean of only 87.79 mm for the Mesa de Maya stock. Considerable variation also is exhibited among the stocks in ear length and femur length.

VARIATION IN PELAGE COLOR

The Mesa de Maya stock is the palest in color of the 8 stocks of the truei group here compared. In reflection-meter readings of pelage color this stock ranks highest for all 3 color screens and for both the dorsal and side stripes (Table VI). For all the readings except reflected blue from the side, the Mesa de Maya stock averages significantly higher than any other stock.

The Deadman Flat, Lincoln, and Tule Canyon stocks form a group which is next to the Mesa de Maya stock in paleness of pelage as shown by the reflection meter readings (Fig. 3). The Capitan Gap stock does not have significantly lower readings than these for dorsal stripe red or side red, but for the other color comparisons it ranks below them.

The Carrizozo stock is significantly lower than any other stock in the color readings for dorsal-stripe red and dorsal-stripe green, and it does not average significantly higher than any other

TABLE VI

Reflection-meter Readings of the Pelage Color of the Peromyscus truei Group

Means, standard errors, and standard deviations of proportion of light reflected from the specimen are in comparison to that reflected from a magnesium carbonate block (taken as 100).

Stock	Age Class	Sex	DORSAL STRIPE			SIDE STRIPE		
			Red	Green	Blue	Red	Green	Blue
truei								
Capitan Gap . .	1 yr.	♂♂	17.85 ± .25 (1.59)	10.08 ± .12 (.74)	6.75 ± .10 (.63)	36.03 ± .56 (3.53)	20.55 ± .29 (1.83)	12.35 ± .17 (1.08)
	1 yr.	♀♀	17.45 ± .26 (1.59)	10.05 ± .12 (.73)	6.66 ± .11 (.67)	36.34 ± .44 (2.68)	19.13 ± .31 (1.88)	11.55 ± .21 (1.29)
	1 yr.	♂+♀	17.65 ± .18 (1.59)	10.06 ± .09 (.80)	6.71 ± .07 (.65)	36.18 ± .35 (3.13)	19.86 ± .22 (1.97)	11.96 ± .14 (1.24)
Deadman Flat .	1 yr.	♂♂	17.48 ± .57 (2.84)	9.92 ± .24 (1.19)	6.84 ± .18 (.90)	35.76 ± .77 (3.85)	20.96 ± .40 (2.01)	12.60 ± .19 (.96)
	1 yr.	♀♀	18.24 ± .28 (1.42)	10.28 ± .23 (1.17)	6.88 ± .16 (.78)	38.36 ± .88 (4.39)	20.52 ± .36 (1.81)	12.32 ± .27 (1.35)
	1 yr.	♂+♀	17.86 ± .32 (2.26)	10.08 ± .17 (1.18)	6.86 ± .12 (.83)	37.06 ± .61 (4.29)	20.74 ± .27 (1.90)	12.46 ± .17 (1.16)
	2 yr.	♂+♀	19.12 ± .39 (2.25)	10.06 ± .21 (1.22)	6.66 ± .14 (.78)	38.73 ± .40 (2.27)	20.91 ± .36 (2.07)	12.15 ± .24 (1.35)
Highrolls A . .	1 yr.	♂+♀	16.40 ± .29 (1.31)	9.40 ± .21 (.94)	6.25 ± .10 (.44)	33.55 ± .63 (2.82)	19.80 ± .47 (2.09)	11.25 ± .32 (1.41)
Mesa de Maya .	1 yr.	♂+♀	20.86 ± .29 (2.14)	13.00 ± .18 (1.34)	8.70 ± .13 (.97)	40.52 ± .63 (4.73)	23.64 ± .28 (2.12)	14.02 ± .16 (1.21)
	2 yr.	♂+♀	19.88 ± .42 (2.63)	12.35 ± .29 (1.83)	8.55 ± .20 (1.26)	41.38 ± .77 (4.89)	24.58 ± .39 (2.48)	14.20 ± .26 (1.64)
nasutus								
Lincoln	1 yr.	♂+♀	17.75 ± .26 (1.99)	11.39 ± .15 (1.13)	7.81 ± .10 (.77)	34.00 ± .47 (3.55)	21.68 ± .25 (1.90)	13.65 ± .21 (1.60)
Rustler Park .	1 yr.	♂+♀	15.45 ± .19 (1.34)	9.72 ± .14 (1.01)	6.51 ± .09 (.65)	29.55 ± .33 (2.34)	17.43 ± .19 (1.32)	10.69 ± .15 (1.07)
	2 yr.	♂+♀	15.63 ± .24 (1.44)	9.57 ± .15 ((.88)	6.34 ± .11 (.64)	30.17 ± .43 (2.54)	17.60 ± .32 (1.91)	10.57 ± .17 (.98)
griseus								
Carrizozo. . .	1 yr.	♂+♀	13.00 ± .23 (2.11)	7.64 ± .14 (1.25)	5.93 ± .09 (.85)	28.22 ± .46 (4.12)	17.63 ± .25 (2.28)	11.98 ± .17 (1.51)
	2 yr.	♂+♀	11.94 ± .38 (2.15)	7.16 ± .21 (1.17)	5.75 ± .11 ((.62)	28.03 ± .55 (3.09)	17.19 ± .39 (2.22)	11.84 ± .26 (1.46)
comanche								
Tule Canyon. .	1 yr.	♂+♀	17.54 ± .23 (1.66)	11.06 ± .13 (.92)	7.22 ± .11 (.77)	36.83 ± .51 (3.71)	21.76 ± .28 (2.06)	13.13 ± .21 (1.52)
	2 yr.	♂+♀	17.20 ± .38 (1.89)	10.56 ± .20 (1.00)	6.76 ± .16 (.78)	38.64 ± .86 (4.28)	23.08 ± .44 (2.22)	13.48 ± .25 (1.26)

stock except for side-stripe blue, in which it significantly exceeds the Rustler Park stock.

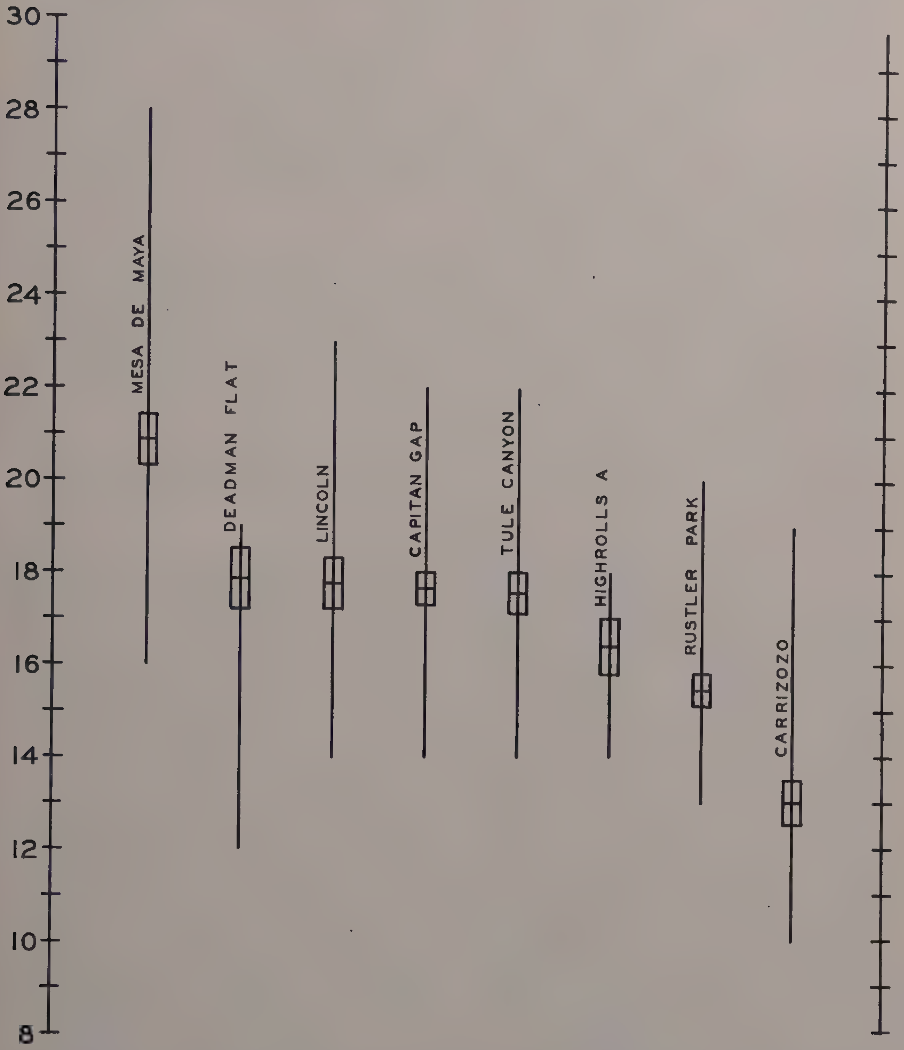


FIG. 3. Variation in reflection-meter readings of reflected red from the dorsal stripe of specimens prepared from laboratory-bred stocks of the Peromyscus truei group, shown by the same graphical method used in Figure 1. One-year age class, both sexes.

The Rustler Park and Highrolls A stocks rank in general just above the Carrizozo stock in color readings, except for blue reflected from the side stripe, for which the Rustler Park stock ranks significantly below the Carrizozo stock.

It may be said, therefore, that of the 8 stocks of the truei group here compared, the stock from Mesa de Maya is the palest and that from Carrizozo is the darkest. The other stocks are intermediate in shade of color. The Deadman Flat, Lincoln, and Tule Canyon stocks are relatively pale and are exceeded in color readings of reflected light only by the Mesa de Maya stock. The Capitan Gap stock ranks slightly darker than these 3 stocks for certain colors. The Rustler Park and Highrolls A stocks are relatively dark, and they rank immediately above the Carrizozo stock in reflection-meter readings.

The pelage colors of these stocks, however, form a fairly evenly graded series. No one of them is clearly distinct from the others in shade of color. The Mesa de Maya stock appears to be most distinct, but many of the individuals of this stock cannot be distinguished in color readings from certain individuals of the other stocks.

No differences in hue between these stocks are apparent. The pigments concerned in producing the pelage colors are believed to be the same in all the stocks, although no microscopic examinations have been made of the hairs.

The relatively dark pelage of the Carrizozo mice is evidently correlated with the black color of the lava soil in the habitat of the subspecies griseus (Bradt, 1932; Benson, 1933; Dice and Blossom, 1937). Likewise the pale color of the Mesa de Maya mice may be presumed to be correlated with the pale color of the rocks of the xeric habitat where the female ancestor of this stock was taken. Museum skins of several other truei collected at the same place are similarly pale. The ancestors of the other stocks which are here described came from habitats in which the surface soils are intermediate in shade between the Malpais and Mesa de Maya soils. No soil samples were collected from most of these habitats, however, and no critical comparison can be made between the pelage color of the mice and the color of the soils of their habitats.

Most of the color measurements given in this paper were taken with a Photovolt reflection meter. These measurements are not directly comparable with those taken with the Hess-Ives tint photometer and published in earlier papers dealing with variation in Peromyscus. For comparison with the readings taken with the tint photometer and previously published, I here present tint-photometer readings of pelage color for a few of these stocks (Table VII).

Both the reflection meter and the tint photometer use color filters to produce red, green, and blue readings, but the wave lengths passed by the filters and the percentage of light transmission

TABLE VII

Tint-photometer Readings of the Pelage Color of Certain Stocks of the Peromyscus truei Group

Means, standard errors, and standard deviations of proportion of light reflected from the specimen are in comparison to that reflected from a magnesium carbonate block (taken as 100). Measurements of males and females are combined.

Stock	Age Class	DORSAL STRIPE			SIDE STRIPE		
		Red	Green	Blue	Red	Green	Blue
truei							
Capitan Gap . . .	1 yr.	15.87 ± .21 (1.84)	11.89 ± .15 (1.35)	9.28 ± .12 (1.01)	26.55 ± .27 (2.37)	19.51 ± .21 (1.81)	14.55 ± .21 (1.89)
Deadman Flat . .	1 yr.	15.79 ± .23 (1.61)	12.25 ± .19 (1.28)	9.63 ± .17 (1.16)	25.83 ± .41 (2.82)	19.04 ± .31 (2.14)	14.38 ± .30 (2.09)
	2 yr.	14.15 ± .63 (3.64)	10.58 ± .43 (2.47)	8.27 ± .32 (1.83)	24.24 ± .91 (5.21)	17.70 ± .68 (3.90)	13.67 ± .57 (3.27)
Highrolls A . . .	1 yr.	10.60 ± .29 (1.29)	8.30 ± .29 (1.30)	5.95 ± .22 (1.00)	19.70 ± .41 (1.81)	14.25 ± .32 (1.41)	9.90 ± .33 (1.48)
Mesa de Maya . .	1 yr.	15.34 ± .39 (2.89)	12.18 ± .32 (2.40)	9.43 ± .28 (2.11)	27.84 ± .50 (3.75)	20.63 ± .37 (2.75)	14.88 ± .29 (2.17)
	2 yr.	12.90 ± .35 (2.20)	10.00 ± .26 (1.63)	7.88 ± .19 (1.19)	26.55 ± .61 (3.83)	20.03 ± .44 (2.75)	13.90 ± .32 (2.02)

TABLE VIII

Reflection-meter Readings of Pelage Color of Hybrids between Various Members of the Peromyscus truei group and of P. n. griseus from Carrizozo

Means, standard errors, and standard deviations of amount of light reflected from the specimens are in comparison to that reflected from a magnesium block (taken to be 100). Males and females are taken together.

Stock Mated with griseus	Gen-era-tion	Age Class	Num-ber	DORSAL STRIPE			SIDE STRIPE		
				Red	Green	Blue	Red	Green	Blue
Rustler Park									
nasutus	F_1	2 yr.	11	12.27 ± .47 (1.56)	8.18 ± .30 (.98)	6.00 ± .23 (.78)	27.91 ± .90 (2.98)	17.36 ± .56 (1.86)	11.73 ± .49 (1.62)
	F_2	1 yr.	41	12.88 ± .31 (1.93)	7.95 ± .19 (1.18)	6.32 ± .13 (.82)	27.22 ± .49 (3.09)	16.78 ± .31 ((1.93)	11.46 ± .18 (1.14)
Lincoln									
nasutus	F_1	2 yr.	17	12.53 ± .36 (1.46)	7.47 ± .19 (.80)	6.59 ± .05 (.20)	29.35 ± 1.24 (5.12)	17.47 ± .59 (2.43)	12.35 ± .32 (1.32)
	F_2	1 yr.	35	11.43 ± .24 (1.42)	7.09 ± .19 (1.15)	5.97 ± .38 (2.23)	25.51 ± .63 (3.71)	16.37 ± .35 (2.06)	11.74 ± .24 (1.44)
Deadman Flat									
truei	F_1	1 + 2 yrs.	16	15.63 ± .60 (2.39)	9.19 ± .39 (1.56)	6.56 ± .33 (1.32)	34.81 ± 1.09 (4.34)	19.56 ± .49 (1.97)	12.25 ± .30 (1.18)

differ for the 2 instruments. In general, the tint photometer gives lower readings than the reflection meter. It would be futile, however, to attempt to compare the readings of the 2 instruments in any quantitative manner.

PELAGE COLOR OF HYBRIDS

Measurements of pelage color are available for a few hybrids of griseus from Carrizozo with other stocks of the truei group (Table VIII). Both the F_1 and F_2 hybrids of crosses of griseus with nasutus from Rustler Park and from Lincoln have color readings which are close to griseus. In a cross with truei from Deadman Flat, however, the F_1 hybrids are more or less intermediate in color readings between the 2 parent stocks. The standard errors of the means are fairly high for most of these pelage color readings of the hybrids, and it seems unwise to attempt to draw any conclusions from these data about the mode of heredity of the dark pelage of griseus.

FERTILITY RELATIONS

Crosses in the laboratory between stocks of the subspecies Peromyscus truei truei taken in various parts of its geographic range have all been at least moderately successful. The F_1 hybrid males and females, so far as they have been tested, have all proved to be fertile (Dice, 1933b; Dice and Liebe, 1937). Crosses between diverse stocks from within the range of the subspecies Peromyscus nasutus nasutus have also been successfully made in the laboratory, and both the male and female F_1 hybrids seem to be as fertile as the mice of the parent stocks.

In addition to the intrasubspecific crosses of nasutus previously reported, I have successfully crossed a stock from Rustler Park in the Chiricahua Mountains of Arizona with individuals of the same subspecies from stations B, C, and E near Highrolls, New Mexico. The Rustler Park stock has also been crossed with a stock of the same subspecies from Lincoln, New Mexico. No difficulty has been encountered in securing the F_2 generation in any of these crosses between stocks of the same subspecies.

Various subspecies of the same species within the truei group have also been successfully crossed in the laboratory. Thus, the 2 subspecies Peromyscus truei truei and P. t. gilberti have crossed in the laboratory and have produced young (Dice, 1933b). The fertility of these F_1 hybrids was not tested, but presumably they would have been fertile. In the species nasutus, the subspecies griseus from near Carrizozo, New Mexico, has been crossed with nasutus from Rustler Park and also with nasutus from Lincoln. In these crosses both the male and the female F_1 hybrids proved to be fertile.

Within any single species of this group of mice, consequently, all the individuals seem to be potentially interfertile, whether or not they are members of the same subspecies and irrespective of the geographic distance that may separate their habitats.

In crosses between species in this group of mice, however, we encounter partial infertility. Peromyscus truei truei and P. nasutus griseus will cross in the laboratory and most of their F_1 female offspring are fertile. The hybrid males, on the contrary, are uniformly infertile and no viable spermatozoa were found (Dice and Liebe, 1937).

In addition to the hybrids between these species previously reported, I have crossed a stock of nasutus from Rustler Park with a stock of truei from Deadman Flat. Of 21 matings only 3 were fertile. Ten hybrid young were reared to weaning age, though others were born that did not survive. Of these 10 F_1 hybrids, 5 were females and 5 males. Of the F_1 hybrid females, one produced no offspring when backcrossed to a nasutus male, but did produce 7 young when backcrossed to a truei male. Another F_1 female produced 2 offspring from a backcross to a truei male. A third female produced no offspring when mated to a truei male. The other 2 females were not tested for fertility. All the F_1 males were infertile in backcrosses, 3 of them being tested with truei females and 2 with nasutus females.

The species Peromyscus comanche from Tule Canyon, Texas, will cross, though with some difficulty, with P. nasutus nasutus from Arizona and from New Mexico. One of 6 F_1 males from such crosses produced young when mated to a comanche female. The other 5 hybrid males produced no offspring, but from examination of their sperm one of them may have been potentially fertile (Blair, 1943).

No attempted crosses between either truei, nasutus, or nasutus with Peromyscus of any other species-group have ever been successful (Dice, 1933b). The evidence, therefore, indicates that the Peromyscus truei group is reproductively isolated from all the other mice of the genus Peromyscus. Within the truei group the 3 species comanche, nasutus, and truei are partly infertile with one another, this being shown particularly by the partial or complete infertility of the hybrid males. The several subspecies and local populations within each of these species, however, seem to be completely interfertile with one another.

SYSTEMATICS

Of the stocks here described, those from Capitan Gap, Deadman Flat, Highrolls A, and Mesa de Maya may be assigned to the species truei on the basis of their size of ear (Fig. 2). The Rustler Park and Lincoln stocks are assigned to nasutus.

Nasutus not only has a smaller ear than truei, but it also has a longer tail. There are, however, considerable differences both in length of ear and of length of tail among the stocks assigned to truei and also among those assigned to nasutus. In addition, the individual variability within the stocks would make it impossible to assign every individual correctly to species on the basis of either ear size or tail length alone.

The Tule Canyon stock is assigned to the species comanche, which in length of ear is closer to the species nasutus than to truei. Breeding tests, however, indicate that comanche is partly infertile in crosses with nasutus (Blair, 1943). No breeding tests have been made with truei. In tail length comanche is closer to truei than to nasutus.

The Carrizozo stock is assigned to the subspecies griseus of the species nasutus. The ears of the mice of this stock are similar in size to those of nasutus and are strikingly smaller than those of truei. The tail averages shorter, however, than in the other stocks of the species nasutus here described and does not differ significantly in length from the tails of the Highrolls, Capitan Gap, and Deadman Flat stocks of undoubted truei. In its fertility relations, griseus is clearly differentiated from truei and is closely related to nasutus.

The evidence seems to indicate clearly that griseus is a subspecies of nasutus not yet sufficiently differentiated to have become even partly infertile when backcrossed. Nevertheless, griseus differs strikingly from nasutus in its shorter length of tail and in its darker pelage color. This demonstrates again that the body proportions and pelage color of mammals often rapidly become modified in the course of evolution.

The occurrence together in the same region and often in the same local habitats of the 2 species truei and nasutus (Dice, 1942) is of especial interest to the student of evolution. These 2 species are closely related and are assigned to the same species group of the subgenus Peromyscus. They are sufficiently closely related so that hybrids can be obtained in the laboratory, although no hybrids have ever been discovered in nature. The partial infertility which exists between the 2 forms is probably sufficient to retain the distinctness between them, even if occasional interbreeding should occur in those situations where both forms occur. It seems probable that miscegenation rarely if ever occurs. So far as I know, no laboratory studies of assortative mating between the 2 forms have been carried out, but it is likely that each form prefers to mate with its own kind.

From what is now known about the conditions under which new species originate through the splitting of an ancestral form, some form of isolation must initially have separated certain of the local populations of the ancestor (Dobzhansky, 1941; Mayr, 1942). Isolation between nasutus and truei must be assumed to have continued for a sufficiently long period of time to result in the development of partial intersterility between the isolated populations. Subsequent to the development of partial infertility, these 2 forms have come to occupy broadly overlapping geographic ranges and habitats.

The pinyon and juniper habitats, in which the 2 species nasutus and truei most frequently live in southwestern North America, are often discontinuous in their distribution. The buttes and small mountain ranges which carry belts of pinyon pines and junipers often are isolated from one another by many miles of desert or grassland habitat inhospitable for the mice of this group. One such isolated butte or mountain range may be occupied by one or other only of these 2 species. In certain places both species occur together. Changes in the climate of the area over past ages have undoubtedly led to frequent changes in the distribution of habitats suitable for these mice, with consequent changes in the degree of isolation between adjacent sites. Abundant opportunities have consequently occurred in the past and still exist for the temporary isolation of small populations of these mice (Dice, 1940: 295).

The species comanche is geographically isolated from both nasutus and truei. It is known to be partly infertile with nasutus. The development of this partial infertility between comanche and nasutus may be presumed to be in considerable part a resultant of its isolation. The conditions of geographic isolation under which comanche has become differentiated from other members of the truei group may be presumed to illustrate the conditions under which at some time in the past, the species truei and nasutus likewise became differentiated from one another.

SUMMARY

Measurements are given of body and skeletal dimensions and of pelage color for 8 laboratory-bred stocks of the Peromyscus truei group of small rodents from the southwestern United States.

Two-year old animals average slightly larger than 1-year old in all body and skeletal measurements except hind-foot length. There is no significant difference in pelage color between the age classes.

Males and females do not differ significantly in any body or skeletal dimension or in pelage color.

Four of the stocks here described are assigned to Peromyscus truei truei, 2 to P. nasutus nasutus, 1 to P. nasutus griseus, and 1 to P. comanche. Nasutus has a shorter ear and a longer tail than truei. Griseus agrees with nasutus in having a relatively short ear, but in tail length it does not differ significantly from truei. Comanche also has a short ear, like nasutus, and a relatively short tail, like truei.

All the stocks of the same species within the truei group which have been tested are fully interfertile and both the male and female F_1 hybrids are fertile. Crosses between species within the truei group, on the contrary, are relatively infertile and the male F_1 hybrids are partly or completely sterile. No cross of a member of the truei group with any other species group has been successful.

The geographic distribution of the mice of the truei group is discontinuous over southwestern North America, because of the discontinuity of suitable habitats. The resulting isolation between the populations and their consequent independent evolution is believed to have been responsible for the origin of the diversity of forms of this group of small rodents represented in the region. The infertility between the species is assumed also to have resulted from long-continued isolation. At the present time the geographic ranges of the species truei and nasutus overlap and both species may live together in the same habitat without interbreeding.

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